FOOD PARTITIONING BETWEEN *SERRANUS SCRIBA* AND *SCORPAENA PORCUS* (PERCIFORMES) ON THE INFRALITTORAL GROUND OF THE SOUTH TYRRHENIAN SEA

by

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ABSTRACT. - Food preferences of *Scorpaena porcus* and *Serranus scriba* were investigated from the stomach contents of fish caught with trammel nets in the Gulf of Palermo (Tyrrhenian Sea). Decapoda Natantia and Decapoda Brachyura were the main preferred prey in the diet of *S. porcus* whereas Decapoda Natantia, Decapoda Galatheidae and Pisces were the preferred prey for *S. scriba.* These results and the values of the index of overlapping alimentary requirements suggested competition for food resources between the two species. A more precise investigation, at species level, of the food remains of the most abundant taxon (Crustacea Decapoda) made it possible to demonstrate that the trophic niche overlap between the two fish is rather narrow and consistent with the habitat niche overlap.

RÉSUMÉ. - Les régimes alimentaires de la rascasse noire, *Scorpaena porcus,* et du serran écriture, *Serranus scriba,* ont été comparés au moyen de différents coefficients et des indices de compétition trophique calculés sur les contenus stomacaux d'individus recueillis à l'occasion d'une campagne biennale d'étude sur la pêche artisanale dans le golfe de Palerme (mer Tyrrhénienne). Les crustacés sont les proies préférentielles pour les deux espèces. Les poissons sont aussi des proies très fréquentes pour *S. scriba,* alors qu'on les trouve rarement dans l'estomac des *S. porcus.* Les annélides polychètes et les mollusques sont toujours des proies accidentelles. Les deux espèces de prédateurs semblent occuper la même niche trophique. L'examen détaillé des crustacés montre toutefois que les décapodes Natantia et les décapodes Brachyura sont les proies les plus fréquentes pour *S. porcus,* tandis que *S. scriba* montre une préférence exclusive pour les décapodes Natantia et les décapodes Galatheidae. L'analyse approfondie des données et la valeur de l'indice de superposition des niches trophiques, lorsque les proies sont identifiées au niveau des genres ou même des espèces, séparent nettement les spectres alimentaires de la rascasse et du serran. On peut donc différencier les niches trophiques de *S. scriba* et de *S. porcus* dans la mer sicilienne. *S. porcus* est surtout inféodé aux substrats durs, alors que *S. scriba* est un chasseur habituel dans l'herbier des Posidonies.

Key-words. - Scorpaenidae, Serranidae, *Serranus scriba, Scorpaena porcus,* MED, Tyrrhenian sea, Feeding, Ecological niche.

Until a few years ago non-industrial fishing in nearshore waters of the Mediterranean Sea was virtually neglected by fisheries researchers, offering very little interest from either a scientific or an economic stand point.

As a consequence of this attitude, the biology and ecology of the coastal species which were exploited by local fishing with trammel net, gill net and other similar methods, were virtually unknown. In recent years this type of fishing has been upgraded to a primary source due to the high prices commanded by fresh fish, the low energy costs involved and the low impact on the environment (Doumenge, 1981). This development

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has greatly stimulated research as a necessary prerequisite for a rational exploitation of renewable coastal resources and, as a spin-off, numerous new data on the biology of several benthic species are now available that integrate our knowledge of fisheries management.

A survey of the yields from trammel net fishing in the Gulf of Palermo (Sicily) was carried out from October 1981 to September 1983 (Arculeo and Riggio, 1988). In addition to data on fisheries, information was obtained on the biology and ecology of local fish fauna. One new set of data showed the abundance of the painted comber *Serranus scriba* (L.) and the scorpion fish, *Scorpaena porcus* L. which were, in fact, the most frequent species caught by fisheries.

Written records on food preferences of *S. scriba* are quite scarce and those that do exist are only approximate (Zolezzi, 1939); they are more abundant and detailed for *S. porcus* (Bell and Harmelin-Vivien, 1983; Khoury, 1984; Harmelin-Vivien *et al.,* 1989).

As our prime goal was to investigate the role of both species of fish in the food web of the area, stomach contents were analyzed and special attention was devoted to decapod crustaceans which, as soon became clear, are the main food items for both species.

MATERIALS AND METHODS

Each month trammel nets were set from dusk to dawn in three selected sites, "Tonnara", "Discarica" and "Torre", at a depth of 15 m, near the fishing village of "Vergine Maria" in the N/W sector of the Gulf of Palermo. Station "Discarica", located in front of a beach used as a dumping ground, is a broad strip of stones and sand; the biotic cover on the hard substrata is characterized by a felt of brown algae of the genus *Halopteris.* Station "Tonnara", located half a mile southward is again a mixed soft and rocky bottom, but the hard substrata are covered by a luxuriant multilayered biokarst. Station "Torre" located half a mile north of "Discarica" is characterized by an undisturbed *Posidonia oceanica* meadow subject to intense hydrodynamism. For more details on fishing activity see Arculeo and Riggio (1988).

The whole catch, stored in ice boxes, was transferred to the laboratory where all fishes were measured and weighed within a few hours of being caught; samples of the selected species were dissected and stomachs were stored deep-frozen at -15°C. A total of 244 *Serranus scriba* and 321 *Scorpaena porcus* samples were examined (51 and 121 respectively had empty stomachs). The vacuity coefficients obtained and the range of fish sizes are summarized in table I.

Table I. - Number and size range (total length cm) of specimens examined and vacuity coefficient obtained.

Species	Stomachs examined	Empty stomachs	Vacuity coefficient	Total length (cm) min - max	mean
Serranus scriba	244	51	0.21	10.0 - 22.5	13.5
Scorpaena porcus	321	121	0.38	8.5 - 22.5	14.5

The stomach contents were washed in a Petri dish and sorted into large zoological groups (food items) using a binocular dissecting microscope. Wet weight of the food items, after removal of surface water by blotting on tissue paper, was obtained on a laboratory balance (precision 0.1 mg) and subsequently rounded to the nearest milligram.

Sorted food items were stored in 75% ethanol and subsequently identified to the lowest possible taxonomic level, with particular emphasis placed on Decapod Crustaceans.

Different indices or coefficients are in use for the analysis of stomach contents depending on the main aim of the investigation; reviews and discussions on different methodologies can be found in Berg (1979), Hyslop (1980) and Macpherson (1979). Indices used in the work under discussion are detailed herein and relevant written work is quoted when appropriate.

$$\text{Vacuity coefficient (V)} = \frac{\text{Number of empty stomachs}}{\text{Number of stomachs examined}}$$

$$\text{Frequency of occurrence (f)} = \frac{\text{Number of stomachs with food item i}}{\text{Number of not-empty stomachs examined}}$$

$$\text{Average number (n)} = \frac{\text{Total number of food item i}}{\text{Number of stomachs with food item i}}$$

$$\text{Numerical percentage (Cn)} = \frac{\text{Total number of food item i}}{\text{Total number of all food items}} \times 100$$

$$\text{Weight percentage (Cp)} = \frac{\text{Total weight of food item i}}{\text{Total weight of all food items}} \times 100$$

Alimentary coefficient (Q) = Cn x Cp (Hureau, 1970).

To assess the importance of the food items, the following categories, based on the values of f and Q (Rosecchi, 1983) were considered:

1) Main preferred prey ($Q > 100$, $f > 0.3$);
2) Main occasional prey ($Q > 100$, $f < 0.3$);
3) Secondary common prey ($10 < Q < 100$, $f > 0.1$);
4) Secondary additional prey ($10 < Q < 100$, $f < 0.1$);
5) Accidental prey ($Q < 10$).

To investigate the overlapping food resources used by the two species, Schoener's formula (1970) was used:

$$T = 1 - 0.5 \sum_{i=1}^{n} | Pxi - Pyi |$$

where Pxi and Pyi are the proportions by number of the food item i respectively in fish x and in fish y.

The index of overlap (T) is 0 where there is no overlap between the two species and is 1 where the same resources are used in the same proportion by the two species. Values higher than 0.6 have been considered significant (Macpherson, 1979).

RESULTS

The analysis of stomach contents highlighted the importance of crustacean decapods that, by weigth, constitute two thirds of the diet of both species (Tables II, III).

Ranking of the food items, as proposed by Rosecchi (1983), showed that Decapoda Natantia, Decapoda Galatheidae and fish are the "main preferred prey" and Decapoda Brachyura are "secondary common prey" for *Serranus scriba;* whereas in the diet of *Scorpaena porcus* the role of Decapoda Brachyura and Decapoda Galatheidae are interchanged and fish become "main occasional prey".

Fish remains were mostly unidentifiable, and only two genera (*Clinitrachus* and *Tripterygion*) were definitely identified in the stomach contents of both species.

Table II. - Stomach contents of *Scorpaena porcus*. f = frequency of occurrence; n = average number per stomach; Cn = numerical percentage; Cp = weight percentage; Q = Cn x Cp = alimentary coefficient. (NI = not identified).

Food item	f	n	Cn	Cp	Q
Pisces	0.20	1.1	6.7	29.1	194.3
Crustacea					
Decapoda Natantia	0.61	2.8	54.1	20.1	1089.8
Paguridea	0.02	1.0	0.6	0.02	< 0.1
Galatheidae	0.17	1.2	6.2	6.8	42.5
Brachyura	0.44	1.2	17.0	41.8	712.2
Decapoda NI	0.02	1.6	1.2	0.6	0.8
Isopoda	0.10	1.3	4.3	1.2	5.3
Amphipoda	0.09	1.3	3.7	0.1	0.4
Mysidacea	0.01	1.0	0.3	< 0.01	< 0.1
Polychaeta	0.07	-	2.6	0.1	0.3
Mollusca					
Bivalvia	< 0.01	1.0	0.2	< 0.01	< 0.1
Gasteropoda	0.03	1.0	1.1	< 0.01	< 0.1
Algae	0.06	-	-	-	-

Table III. - Stomach contents of *Serranus scriba*. f = frequency of occurrence; n = average number per stomach; Cn = numerical percentage; Cp = weight percentage; Q = Cn x Cp = alimentary coefficient. (NI = not identified).

Food item	f	n	Cn	Cp	Q
Pisces	0.36	1.3	10.2	30.1	305.5
Crustacea					
Decapoda Natantia	0.68	3.4	49.8	27.7	1379.1
Paguridea	< 0.01	1.0	0.1	0.02	< 0.1
Porcellanidae	0.14	1.1	3.4	2.2	7.4
Galatheidae	0.50	1.8	18.6	24.1	448.2
Brachyura	0.24	1.1	5.7	12.9	73.5
Decapoda NI	0.10	1.8	3.9	< 0.01	< 0.1
Isopoda	0.10	1.4	3.1	0.6	1.9
Amphipoda	0.03	1.0	0.7	0.02	< 0.1
Mysidacea	0.07	1.0	1.5	0.1	0.2
Polychaeta	0.04	-	0.8	0.7	0.6
Mollusca					
Cephalopoda	0.01	1.0	0.2	1.5	0.3
Gasteropoda	0.03	1.0	0.7	< 0.01	< 0.1
Algae	0.06	-	-	-	-

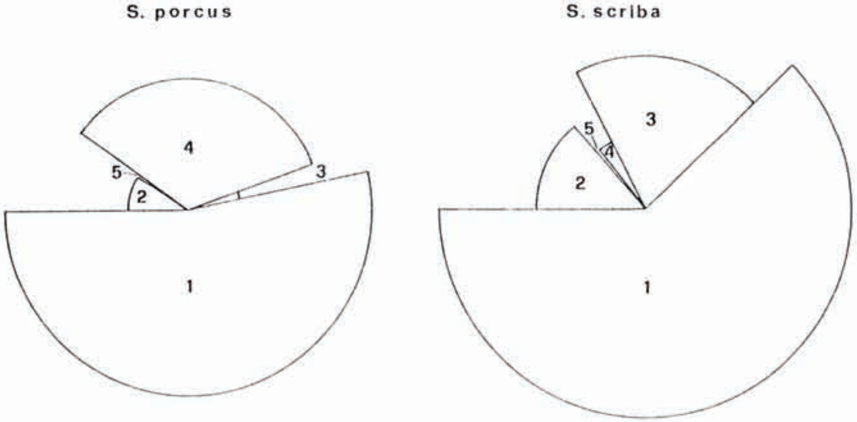

Fig. 1. - Food spectra obtained for *Serranus scriba* and *Scorpaena porcus*. Radius is proportional to the frequency of occurrence of the food item (f), sector width is proportional to the alimentary coefficient (Q). (1 = Decapoda Natantia; 2 = Pisces; 3 = Decapoda Galatheidae; 4 = Decapoda Brachyura; 5 = others).

Peracarid crustaceans as well as mollusks and polychaete worms appeared to be only accidental prey. In this investigation Polychaeta were recorded mostly by the presence of setae in stomach contents, and, when the number of prey was impossible to evaluate, it was assumed to be equal to 1; therefore their alimentary coefficient (Q) may be somewhat underestimated. Nevertheless, the low frequency of occurrence suggests this food item is very marginal in the diet of *Serranus scriba* and *Scorpaena porcus* even if it is an important component of the benthic biomass.

The food item spectra of the two species are graphically represented in figure 1 using the nutrition coefficient and the frequency of occurrence.

It would appear that Brachyura and Galatheidae are the only food items that quantitatively differentiated the diet of *S. porcus* from that of *S. scriba*, and, as a result of the broad taxonomic categories being considered, the alimentary niche overlap between the two species seemed to be rather high (T = 0.77). Such a high alimentary overlap did not match the habitat niche overlap (0.23) computed on the frequency of the two species in the 3 sampling sites. In fact, both species were caught all year round in all three stations, but *S. scriba* was found to be more abundant in the station "Torre" characterized by a *Posidonia oceanica* meadow, whereas *S. porcus* predominated in the catches of the station "Tonnara" where patches of sand alternate with rocks and with algal cover.

The hypothesis of a partitioning of alimentary resources is ruled out when the niche overlap index is computed on the data from the identification of decapod crustaceans at generic or specific levels whenever possible. Thirty different species of Decapods (Table IV) were identified and the new values of niche overlap index evidenced in all sampling stations showed only a moderate trophic overlap between the two species (Table V). This overlap would probably be even smaller if we were able to identify all the fish remains at least at generic level.

The study of decapod prey highlighted fundamental quantitative differences between the two predators. For example the hippolytid shrimps of the genera *Thoralus* and *Hippolyte* usually abundant in *Posidonia* meadows and the alpheid *Alpheus dentipes*, quite common among *Posidonia* roots, were dominant in stomach contents of *Serranus scriba*, whereas *Processa edulis* and *Processa robusta* (grouped in Table V under the heading "*Processa* group *edulis*") were the commonest crustaceans in the stomachs of *Scorpaena porcus*. Processid shrimps prefer sedimentary bottoms where they bury themselves during the day time, being active mostly at night (Noel, 1972). Hence their

Table IV. - Numerical percentage (Cn) and frequency of occurrence (f) of decapod crustaceans in the stomach contents of *Serranus scriba* and *Scorpaena porcus*. (NI = not identified).

Prey	*Serranus scriba*		*Scorpaena porcus*	
	Cn	f	Cn	f
Palaemon xiphias	0.9	0.04	2.3	0.06
Palaemon NI	0.4	0.01	0.3	0.01
Brachycarpus biunguiculatus	0.4	0.02	-	-
Sicyonia carinata	0.3	0.01	0.8	0.02
Lysmata seticaudata	2.2	0.09	0.6	0.01
Hippolyte inermis	0.7	0.03	0.8	0.02
Hippolyte longirostris	2.0	0.07	0.5	0.01
Hippolyte NI	2.4	0.11	2.8	0.05
Thoralus cranchii	10.4	0.23	2.5	0.07
Eualus occultus	2.0	0.07	0.5	0.01
Philocheras spp.	0.2	0.01	0.8	0.02
Athanas nitescens	5.1	0.14	8.2	0.17
Alpheus dentipes	18.1	0.41	3.6	0.10
Alpheidae NI	0.9	0.04	0.5	0.01
Processa group *edulis*	0.9	0.04	22.6	0.34
Natantia NI	3.0	0.07	7.4	0.11
Upogebia sp.	0.1	0.01	-	-
Paguridea	0.1	0.01	0.2	0.02
Pisidia spp.	3.3	0.14	-	-
Porcellana platycheles	0.1	0.01	-	-
Galathea squamifera	4.7	0.19	1.9	0.06
Galathea bolivari	10.5	0.28	2.5	0.06
Galathea cenarroi	0.4	0.02	-	-
Galathea NI	2.9	0.13	1.9	0.06
Liocarcinus arcuatus	0.4	0.01	1.8	0.05
Liocarcinus corrugatus	0.3	0.01	2.0	0.05
Liocarcinus NI	0.3	0.01	1.1	0.03
Xantho pilipes	0.3	0.01	-	-
Xantho granulicarpus	0.3	0.01	1.6	0.05
Xantho NI	0.4	0.02	1.6	0.05
Pilumnus hirtellus	0.4	0.02	0.9	0.03
Pilumnus villosissimus	1.3	0.06	2.0	0.06
Pilumnus NI	0.3	0.01	0.3	0.01
Pisa spp.	0.1	0.01	1.6	0.05
Acanthonyx lunulatus	0.6	0.02	1.2	0.04
Macropodia spp.	0.3	0.01	0.8	0.02
Inachus phalangium	0.1	0.01	-	-
Achaeus spp.	0.1	0.01	0.3	0.01
Ilia nucleus	0.1	0.01	0.3	0.01
Brachyura NI	0.1	0.01	1.7	0.05
Decapoda NI	3.9	0.10	1.2	0.02

Table V. - Alimentary niche overlap values obtained for each station using data from the broad taxa identification (B) and the specific decapods identification (Sp). Number of fish with "not empty" stomachs collected at each station is also given.

Station	Torre	Discarica	Tonnara	All stations
Scorpaena porcus	18	32	151	201
Serranus scriba	157	28	8	193
Niche overlap (B)	0.80	0.68	0.54	0.77
Niche overlap (Sp)	0.55	0.52	0.26	0.48

frequency in the stomachs of *S. porcus* allows us to infer a nocturnal predatory activity of this fish on the sandy grounds surrounding the rocky outcrops of the "Torre" station.

Three species of Anomura: *Galathea squamifera, Galathea bolivari* and *Pisidia* sp., the first two characteristics of *Posidonia* meadows, were common in the stomach of *S. scriba* and rare in the stomach of *S. porcus*. The reverse was true for the Brachyuran families Xanthidae, Portunidae and Majidae.

DISCUSSION

Field studies of food preferences based on stomach content analysis face a number of problems. Most of the time a quantitative sampling of the possible prey of a demersal fish is not feasible and fish proved to be more efficient than scientific sampling equipment. For example the only record of *Richardina fredericii* in the Catalan Sea is based on a specimen found in the stomach of a *Phycis blennoides* (Macpherson, 1978), and the stomach of an *Arnoglossus laterna* yielded the only known specimen of *Athanas amazone* in the Adriatic Sea, an area intensively sampled in the last century (Froglia and Argenti, in press).

The possibility of a bias in the evaluation of food preferences from analysis of stomach contents of predators caught with trawl nets, was illustrated by Judkins and Fleminger (1972) who demonstrated predatory activity inside the net during the haul. Although this does not occur with fish caught with trammel nets, unfortunately another difficulty arises with material obtained with trammel nets. The problem is that the activity of enzymes continues after fish have become entangled in the net, up until the point when the stomach is dissected and preserved. Thus in the stomachs of fish entangled several hours before net hauling, the food remains are more digested and not always countable or identifiable: this is especially true for prey such as polychete worms with few or no hard structures.

It is well known, as also demonstrated by Froglia (1988) for *Mullus barbatus* in an Adriatic nursery ground, that fish diets can change according to the abundance of different prey in the environment, provided these prey are within the selected size range and have similar ecological characteristics. Moreover the importance of different food items may change as the predator grows. These facts should be kept in mind when data from different authors are compared.

Only sparse qualitative data (Zolezzi, 1939) were previously available on the feeding preferences of *Serranus scriba*. Our study confirmed the importance of fish and decapod crustaceans and, for the sampled area, demonstrated the importance of *Galathea* spp. and of other species associated with the *Posidonia* roots cryptic habitat (Alphaeidae) or the *Posidonia* leaves (*Hippolyte* spp.).

More information is available for *Scorpaena porcus*, the commonest scorpion-fish in the Mediterranean and there is broad agreement between our findings and those of Bell and Harmelin-Vivien (1983), Khoury (1984) and Harmelin-Vivien *et al.* (1989).

The low frequency of Amphipods observed in this investigation is most probably due to the absence in our samples of specimens of *S. porcus* smaller than 80 mm in total length. In fact, Harmelin-Vivien *et al.* (1989) observed a rather abrupt decrease in the percentage of Amphipods in the stomachs of specimens with an average length of more than 60 mm. Other minor differences, such as the higher frequency of Alpheidae recorded in our samples may simply be the result of the different abundance of these prey in the investigated habitats.

Prawns of the genus *Hippolyte* were not uncommon in the stomachs of *Serranus scriba*, but rather scarce in the stomachs of *S. porcus*, as already highlighted by Harmelin-Vivien *et al.* (1989). Their report suggests several hypotheses to explain the scarcity of a food item which is normally commonly found in the sampled environment. Our findings for *S. scriba* weaken the hypothesis of avoidance caused by the presence of toxic substances in *Hippolyte* and add more weight to the alternative hypothesis involving predator behaviour. Moreover Noel (1985) reported a mimetic homochromy for these prawns.

The two approaches used to estimate the alimentary niche overlap came to rather different conclusions. This result is rather obvious, but still worthy of mention. The first approach, based on the classification of prey into broad taxonomic groups, may be sufficient to classify a predator within a general ecological scheme: both *Scorpaena porcus* and *Serranus scriba* fall into the feeding category of the "macrophagic carnivores" as defined by Bell and Harmelin-Vivien (1983).

However only the second approach, based on a finer classification down to the specific or generic level (Table V), makes it possible to correctly understand a section of the food web in a restricted area and the interspecific relationships that may control the abundance of a species.

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